

NDCEE

National Defense Center for Environmental Excellence



DoD Executive Agent
Office of the
Assistant Secretary
of the Army
(Installations and
Environment)

Conversion of Wood Debris into Alternative Construction Materials

Presented by:
Howard Weinick, NDCEE

**12th Annual Joint Services Environmental
Management Conference & Exhibition
May 21-24, 2007**

DISCLAIMER: The contents of this document are not to be used for advertising, publication, or promotional purposes. Citation of trade names does not constitute an official endorsement or approval of the use of such commercial products. All product names and trademarks cited are the property of their respective owners. The findings in this document are not to be construed as an official Department of the Army position unless so designated by other authorized documents.

The NDCEE is operated by:  *Concurrent Technologies Corporation*

Technology Transfer—Supporting DoD Readiness, Sustainability, and Transformation

Report Documentation Page				Form Approved OMB No. 0704-0188	
Public reporting burden for the collection of information is estimated to average 1 hour per response, including the time for reviewing instructions, searching existing data sources, gathering and maintaining the data needed, and completing and reviewing the collection of information. Send comments regarding this burden estimate or any other aspect of this collection of information, including suggestions for reducing this burden, to Washington Headquarters Services, Directorate for Information Operations and Reports, 1215 Jefferson Davis Highway, Suite 1204, Arlington VA 22202-4302. Respondents should be aware that notwithstanding any other provision of law, no person shall be subject to a penalty for failing to comply with a collection of information if it does not display a currently valid OMB control number.					
1. REPORT DATE MAY 2007		2. REPORT TYPE		3. DATES COVERED 00-00-2007 to 00-00-2007	
4. TITLE AND SUBTITLE Conversion of Wood Debris into Alternative Construction Materials				5a. CONTRACT NUMBER	
				5b. GRANT NUMBER	
				5c. PROGRAM ELEMENT NUMBER	
6. AUTHOR(S)				5d. PROJECT NUMBER	
				5e. TASK NUMBER	
				5f. WORK UNIT NUMBER	
7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES) National Defense Center for Energy and Environment (NDCEE), Concurrent Technologies Corporation, 100 CTC Drive, Johnstown, PA, 15904				8. PERFORMING ORGANIZATION REPORT NUMBER	
9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)				10. SPONSOR/MONITOR'S ACRONYM(S)	
				11. SPONSOR/MONITOR'S REPORT NUMBER(S)	
12. DISTRIBUTION/AVAILABILITY STATEMENT Approved for public release; distribution unlimited					
13. SUPPLEMENTARY NOTES					
14. ABSTRACT					
15. SUBJECT TERMS					
16. SECURITY CLASSIFICATION OF:			17. LIMITATION OF ABSTRACT Same as Report (SAR)	18. NUMBER OF PAGES 25	19a. NAME OF RESPONSIBLE PERSON
a. REPORT unclassified	b. ABSTRACT unclassified	c. THIS PAGE unclassified			

Presentation Overview



- Background
- Technology Concept
- Process Description
- Preliminary Feasibility Study
- Additional Resources

U.S. Army Construction and Demolition (C&D) Waste



Around 20 million tons of building related debris projected over 15 years



Goal to divert minimum 50% by weight of debris from landfills



Army Wood Debris- Potential Quantities



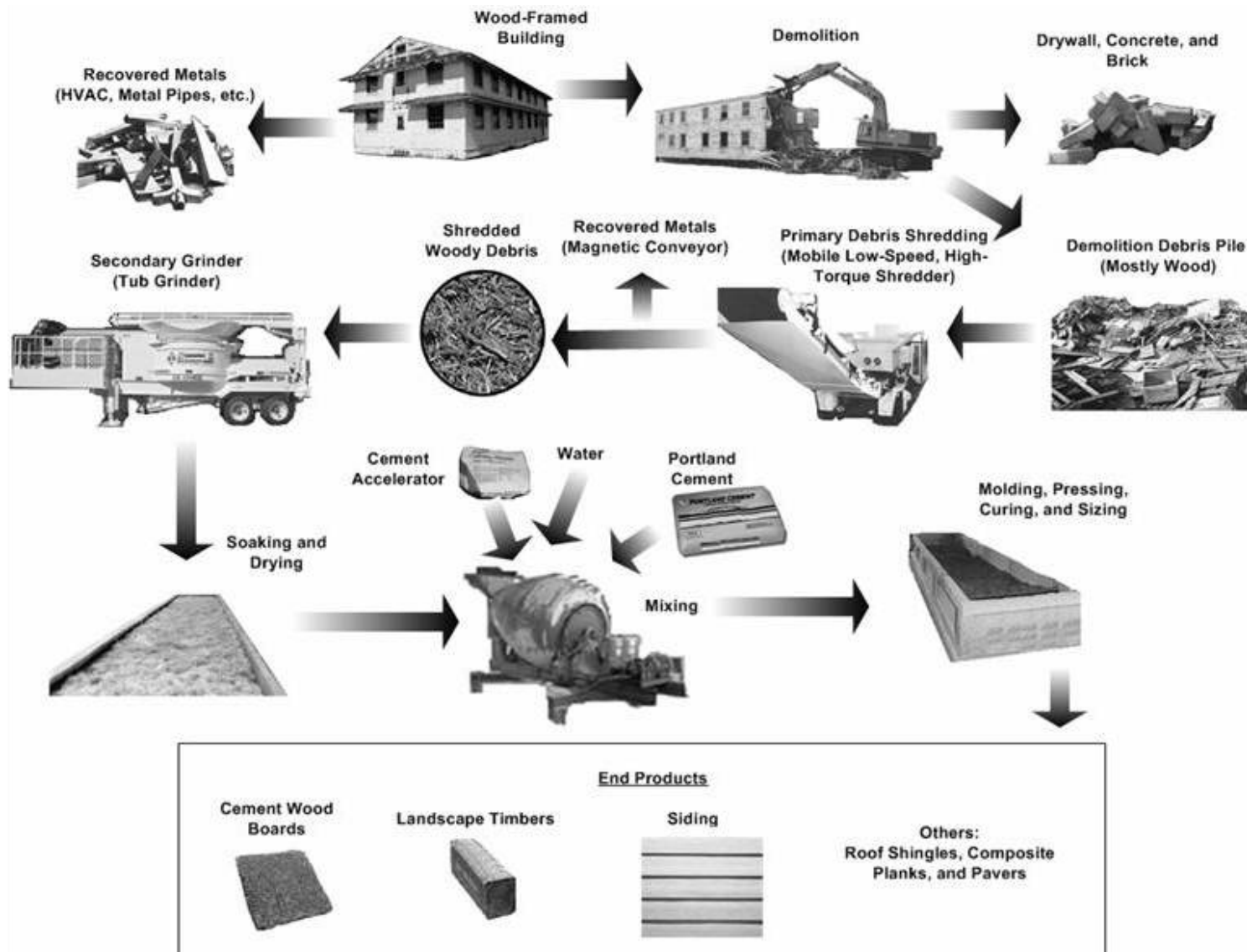
- WWII-era 2-story wood barrack:
 - 30,000 board feet (50,000 linear feet) of total wood materials
- Estimated 250 million board feet of wood available in Army WW-II building inventory slated for removal
- *Army-Wide Survey Numbers*

Data Sources:

1. Draft ECTP Demonstration Plan: Reclamation of Wood Materials Coated with LBP, ERDC-CERL, 2004.
2. Alternatives To Demotion: Opportunities to Reduce Solid Waste through Deconstruction, Reuse, & Recycling of Building Materials, ERDC-CERL Presentation, 2002.
3. Alternatives to Demolition: Opportunities to Deconstruct, Reuse, & Recycle Materials from Army Building, DoD Deconstruction Training SWANA ERDC-CERL, 2003.
4. Falk, R., Janowiak J., Beakler, B., Lampo, R., and Napier, T., "Remilling of Salvaged Wood Siding Coated with Lead-Based Paint, Part II. Wood Product Yield," Forests Products Journal, Vol 55, No. 7/8, July/August 2005, pp. 81-86

CEHNC Concept:

- Rapid removal of Army wood buildings with a means to divert large volumes of C&D debris materials
- NDCEE was tasked to:
 - Define technology concept
 - Conduct preliminary feasibility study



Typical Material Composition of 2-Story WWII-Era Wood-Framed Army Barrack

Materials	Total Quantities		Composition By Weight
	(tons) ¹	(lbs)	
Asphalt Shingles	3	6,000	3%
Brick	9	18,000	8%
Concrete	22	44,000	20%
Drywall	20	40,000	18%
Metals	2	4,000	2%
Miscellaneous ²	1	2,000	1%
Plastics	1	2,000	1%
Wood	52	103,000	47%
Total	110	219,000	100%



Feedstock: Woody Demolition Debris

Process Input Composition Following Demolition and Material Segregation

Materials	Material Input Quantities Per Demolished Barrack (lbs)	Weight Composition
Asphalt	6,000	4%
Brick	*	--
Concrete	*	--
Drywall	40,000	26%
Metal	800	0.5%
Miscellaneous	2,000	1%
Plastic	2,000	1%
Wood	103,000	67%
Total	153,800	100%

* Normally recycled for reuse.



Demolition



**Mobile Low Speed High
Torque Grinder**

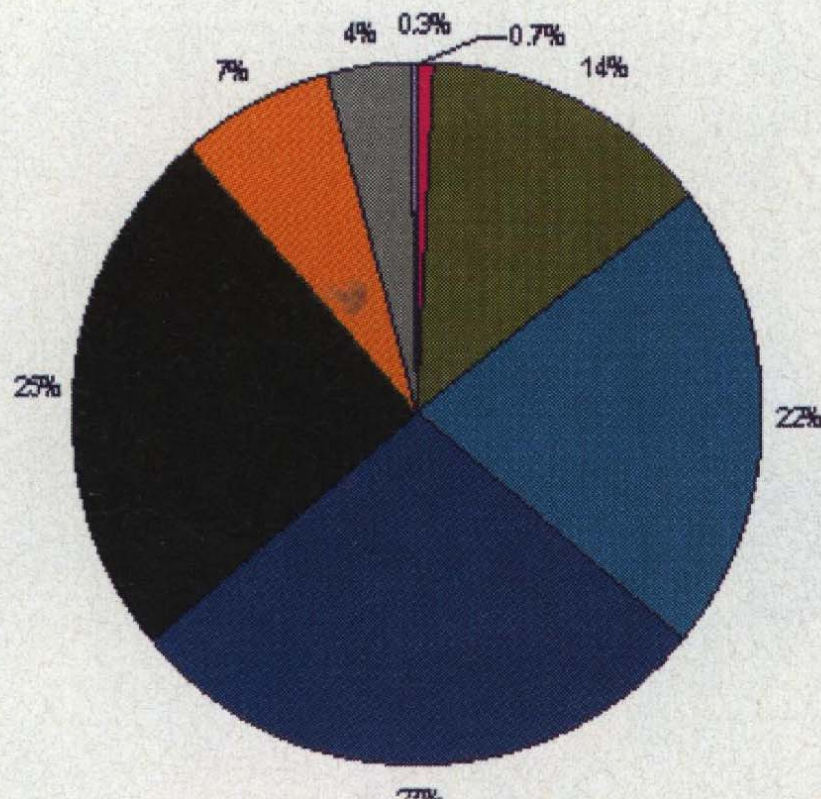


Tub Grinder

Feedstock: Wood Debris from Disaster Areas



Figure 1. Markets for Hurricane-Generated Mulch (2004)*



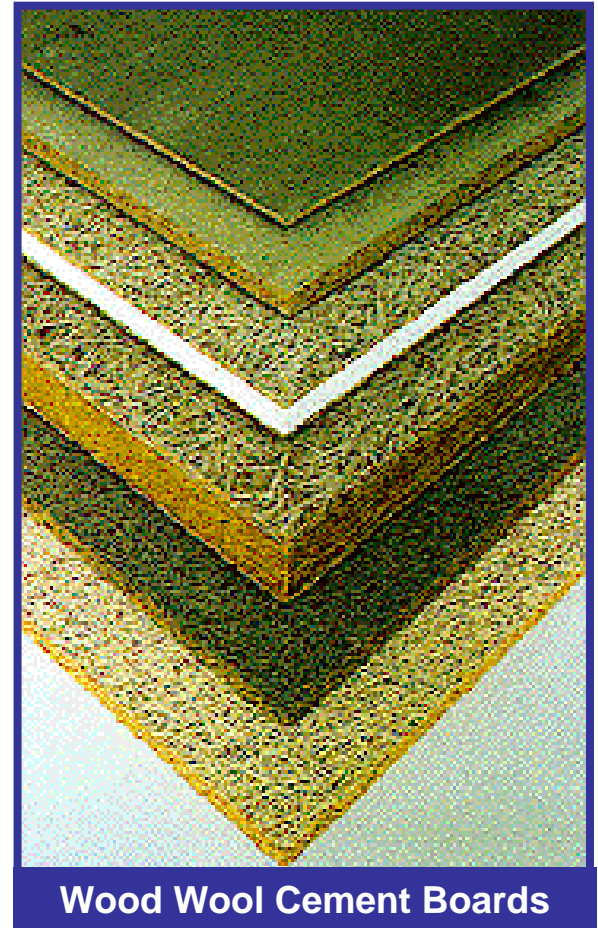
Source:
Burgeil, J., McLendon, C., "Green Sweep: Florida Communities Reel From
Hurricanes, Learn Valuable Lessons, MSW Management
Sep/Oct 2005.

■ Burn ■ Domestic Power ■ Export Power ■ Landfill Disposal ■ Daily Cover ■ Composting ■ Landscaping/Ground Cover ■ Other

Alternative Market

■ End Product: Cement-Bonded Wood Composite

- Alternative concrete products made by combining Portland cement with wood particles in place of conventional aggregate
- Properties
 - Lighter than conventional concrete
 - High insulating value
 - Resistant to frost, rot, water, fire, and termites
 - Good sound absorption
- Produced using rudimentary tools and unskilled labor



Wood Wool Cement Boards

■ End Product: Cement-Bonded Wood (Cont'd)

- Wide range of external and internal uses, including as substitutes to:
 - Plywood
 - Drywall
 - Non-structural applications such as siding and sheathing
- Easily molded into a variety of common construction forms
 - Planks, blocks, lumber
 - More complex shapes may require the use of an extruder



Houses Made With Cement Wood

Properties of Cement-Bonded Wood Composite Boards

Density:	450 kg/m ³ (medium density) to 750 kg/m ³ (high density)
Acoustic Insulation:	Sound reduction of 10 mm thick board = 31 dB
	Sound reduction of 20 mm thick board= 33 dB
Fire Resistance:	5 cm thick board = 1 hour of resistance
	10 cm thick board = 2 hours of resistance
Thermal Resistance:	Thermal conductivity (k value)=0.35 W/m.K;Linear thermal expansion=0.01 W/m.K
Water Resistance:	Thickness swelling:
	<1.0% after 2 hours of soaking
	<1.5% after 24 hours of soaking
	<2.0% after >24 hours of soaking
Bending Strength:	10–15 N per cubic mm
Load Capacity:	Design Load = 50 psf, Ultimate Load = 200 psf
Compressive Strength:	15 N per cubic mm
Modulus of Elasticity:	4500 Nm

Source: <http://sres.anu.edu.au/associated/fpt/cfb/properties.html#org>, December 2005.

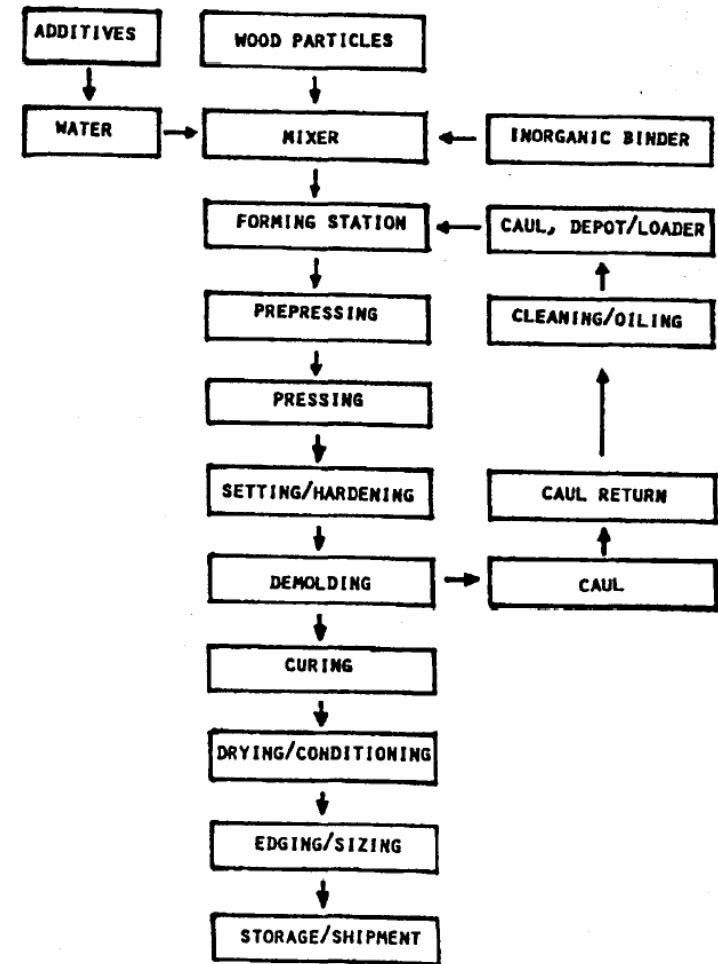
Manufacturing of Cement-Bonded Wood Composites



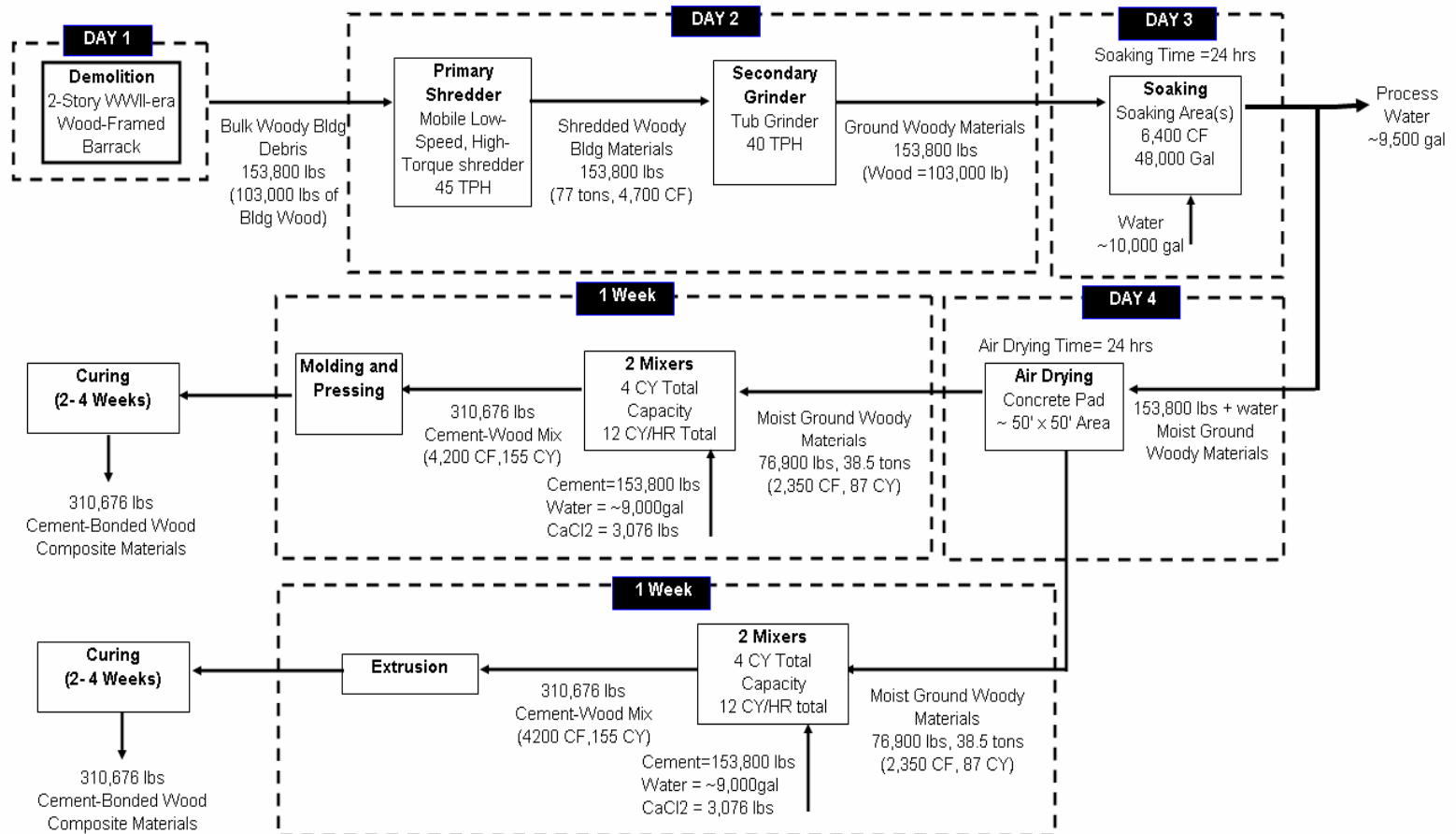
Molding



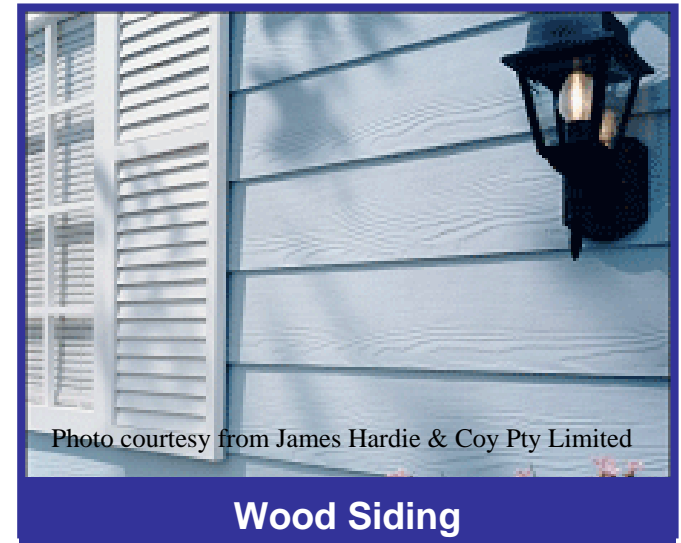
Stacking and Storage



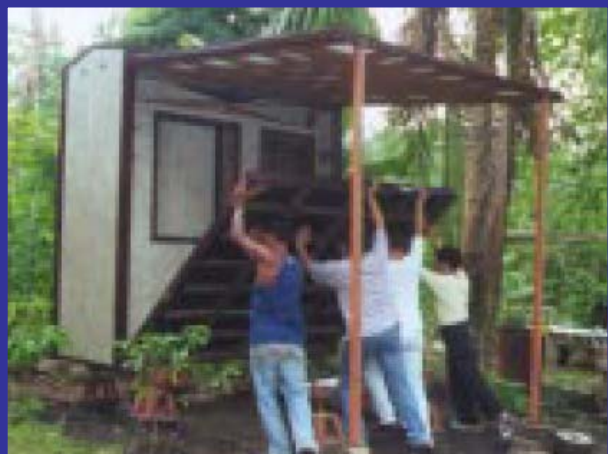
Process Time for Cement-Bonded Wood Manufacturing



Commercially Available Cement Wood Products



On-Site Applications



Storage Sheds and Emergency Shelters



Housing

Preliminary Economic Analysis

	Cost	Unit	Description
Initial Investment	\$2 million	Lump Sum	Equipment Costs
Processing Cost	\$66,000	Per Barrack	Demolition, Utilities, Labor, Materials, and Equipment Operation Costs <ul style="list-style-type: none"> •Demolition cost of \$4 /sq ft (\$35/ton landfill fee) •Processing cost rate of \$12.70/sq ft
Cost Saving	\$70,000	Per Barrack	End product value & landfiling cost avoidance Assumes all wood cement board produced (~4000 per barrack) replaces base use of plywood (~\$15 each)
Cost Benefit	\$4,000	Per Barrack	

Caveats

- **Wood feedstock commingled with non-wood (C&D) materials**
 - **Producibility**
 - **Quality**
 - **Properties**
- **Hazardous materials – lead-based paint, asbestos, etc.**
- **Process (soaking) water contaminants**
- **Regulatory requirements and permits**

Further Development

- **Proof of Concept Testing**
- **Material Testing**
- **Process Refinement**
- **Regulatory Permitting Survey**
- **End Product Market Survey**
- **Additional Cost Analysis**

Resources on Cement-Bonded Wood Composites

■ Articles and Studies

- “Cement and Wood-Wool Combine to Improve Philippine Housing,” [http://www.aciar.gov.au/web.nsf/att/ACIA-5KE7UT/\\$file/Cement_wood-wooPart14.pdf](http://www.aciar.gov.au/web.nsf/att/ACIA-5KE7UT/$file/Cement_wood-wooPart14.pdf)
- “Wastes Into Wood: Composites Are a Promising,” <http://www.ehponline.org/docs/1994/102-2/innovations.html>
- “Durability and Strength of Cement Bonded Wood Particle Composites Made from Construction Waste,” <http://www.fpl.fs.fed.us/documnts/pdf1999/wolfe99a.pdf>
- “Production, Properties, Applications Of Various Wood Cement Products,” <http://www.panelworldmag.com/vserver/hb/display.cfm?MagazineKey=6&IssueKey=453&SectionKey=389&ArticleKey=620>

Resources on Cement-Bonded Wood Composites

■ Organizations

- Australian Centre for International Agriculture Research and Australian National University: <http://www.aciar.gov.au/>
- Philippine Wood Cement Board Industry Website: <http://sres.anu.edu.au/associated/fpt/nwfp/woodwool/woodwoolphil.html>
- USDA Forests Products Laboratories: <http://www.fpl.fs.fed.us>

Questions & Comments



Acknowledgements

- NDCEE Executive Agent
- NDCEE Program Director
- NDCEE Program Manager
- Government Technical Monitor
- NDCEE Project Manager

Mr. Tad Davis, DASA (ESOH)

Mr. Tom Moran, ODASA (ESOH)

Dr. Charles Lechner, ODASA ESOH)

Dr. Eddy Smith, PE, DEE ERDC-CERL

Mr. Bill Boone, NDCEE

Contacts

Mr. Bill Boone
NDCEE - CTC
727-549-7251

boonew@ctc.com

Mr. Howard Weinick
NDCEE - CTC
727-549-7221

weinickh@ctc.com

Dr. Eddy Dean Smith
ERDC-CERL
(217) 373-3488

edgar.d.smith@erdc.usace.army.mil

Acknowledgment: The research described herein was sponsored by the Office of the Deputy Assistant Secretary of the Army for Environmental, Safety, and Occupational Health, Department of the Army, and performed by the NDCEE under contract W74V8H-04-D-0005, Tasks 424 and 449.